https://dx.doi.org/10.22161/ijaers/3.10.15 ISSN: 2349-6495(P) | 2456-1908(O)

Studies Assessing the Effects of Prolonged Standing at Work: A Review

A. S. Shaikh, Rahul D. Shelke

Department of Mechanical Engineering, EES COET, Aurangabad, India

Abstract— *Prolonged standing during working hours is prevalent in industries. Standing is a natural human posture and possesses no specific health risk. However, prolonged standing plays a vital role in numerous health problems. This study is a review of the work done by researchers in the past on industrial workers, who stand for long time during working hours. This type of study is imperative to understand and improve the existing methods used to reduce health risk associated with prolong standing. To know the impact of different conditions on performance of an individual while standing, many researchers used subjective as well as objective methods. Subjective methods are often considered unreliable for decision making, whereas objective methods often give almost reliable results for decision making. Fatigue is more appropriate factor than pain or discomfort when it comes to evaluate individual performance. Researchers need to concentrate more on physical exertion to analyses the performance of any individual, rather than on its by-products e.g. fatigue, pain or discomfort. Studies need to be carried out on large population and for longer duration with continuous observation to further understand and estimate the accurate effects of prevalent methods to reduce health risk. Most of the researchers reported that use of soft mat may help reduce adverse health effects of prolonged standing, but some concluded that it doesn't have significant effect.*

Keywords— Prolong Standing, Energy Expenditure, Anti-Fatigue Mat, Fatigue, Pain, Discomfort.

I. INTRODUCTION

Many nations are taking a lot of efforts to boost industrialization to meet the growing demand of products and services. Growing demand of economical and quality products has enforced the traditional way of manufacturing to transform to the mass production industries. This revolution demands an industrial worker to be more active than earlier to tune their frequency with modern work and machines.

With the growing industrialization, there is a huge need for anthropomorphically designed work spaces, machines and tools. Ergonomics at work improves efficiency of workers, saves time and energy, which has a direct impact on productivity. Pain is costly to employers. Pain is an inordinately common and disabling condition in the workforce. Pain leads to loss of productive time while the employees are at work and consequently leads to reduced performance (Walter F. Stewart, et al. (2003). Good ergonomics is good business. Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance (As of 10 October 2016, International Ergonomics Association (IEA), "www.iea.cc").

Prolonged standing during working hours is very common in many industries. Prolonged standing has some short term as well as long term health risks, very immediate and common are pain, discomfort, fatigue, etc.…. Standing is a natural human posture. Standing itself possesses no specific health risk. However, prolong standing plays a vital role in numerous health hazards which includes work-related musculoskeletal disorder, chronic venous insufficiency, postural kyphosis, varicose veins, joint- compression, muscle fatigue, problems in pregnancy, preterm birth, spontaneous abortion, carotid atherosclerosis, etc.… (Shaikh Abdus Samad, et al. (2016)).

This study is a review of the work done by researchers in the past on industrial workers, who stand for long time during working hours. These studies were designated to help industrial workers reduce adverse effects on health due to prolonged standing without changing their work posture. These studies were mainly concerned with modification of footwear or floor to derive appropriate results.

This type of study is imperative to understand and improve the existing methods used to reduce health risk associated with prolong standing.

II. LITERATURE REVIEW

Jeremy Brownie, et al. (2015), evaluated fatigue of sixteen individuals standing in laboratory environment, for five hours on three different surfaces (linoleum tiles,

https://dx.doi.org/10.22161/ijaers/3.10.15 ISSN: 2349-6495(P) | 2456-1908(O)

rubber mat and sole insert) quantified by Surface-ElectroMyoGraphy (sEMG) measurement technique. The data was collected at the start, middle and end of the day to interpret the results. Jeremy Brownie, et al. (2015), concluded that standing work induces lower limb muscle fatigue with long lasting effects not consciously perceived. Floor mats or sole inserts do not appear to mitigate muscle fatigue. Age effects are not conspicuous in this context of low level sustained exertion.

Javad Aghazadeh, et al. (2015), evaluated pain of sixteen individuals standing in laboratory environment, for two hours on two different surfaces (polyurethane foam 14.5 mm mat and concrete floor) quantified by surface electromyography and Visual Analogue Scale (VAS) measurement technique. The data was collected at the interval of fifteen minutes to interpret the results. Javad Aghazadeh, et al. (2015), concluded that the anti-fatigue mat may be useful in reducing the low back pain although it objectively didn't significantly change the gluteus medius co-activation pattern related to the low back pain.

H. Isa, et al. (2013), evaluated fatigue of ten individuals standing in real work environment, for five hours and forty-five minutes on two different task (metal stamping process and handwork section), quantified by surface electromyography measurement technique. The data was collected at the start, middle and end of the day to interpret the results. H. Isa, et al. (2013), concluded that muscle activity of the workers was determined by the work load and duration of standing. This study suggests that anti fatigue mat and micro breaks should be provided to the workers to reduce muscle fatigue.

Yen-Hui Lin, et al. (2012), conducted two experiments to evaluate discomfort of workers. Experiment #01: ten individuals standing in laboratory environment, for four hours on two different surfaces (12.5 mm thick mat and force plate) quantified by center of pressure weight shift and Likert scale measurement techniques. The data was collected each hour for five minutes for center of pressure weight shift and by Likert scale at the end of the day to interpret the results. Experiment #02: fourteen individuals standing in real work environment, for four hours on two different surfaces (12.5 mm thick mat and concrete floor) quantified by thigh and shank circumferences and Likert scale measurement technique. The data was collected at the start, middle and end of the day for thigh and shank circumferences by gulick tape and by Likert scale end of the day to interpret the results. Yen-Hui Lin, et al. (2012), concluded that subjective discomfort ratings were related to floor type, shoe condition, and standing time. Common ergonomic interventions, such as modifying the flooring on which workers stand might somewhat alleviate legerdemain for workers standing for 4-h shifts in laboratory and field settings. Prolonged standing for even 1 h without rest showed negative effects and should be avoided when possible.

Phyllis M. King, (2002), evaluated fatigue and discomfort of twenty-two individuals standing in real work environment, for eight hours, on four different surfaces (hard floor, floor mat, shoe in-soles and shoe in-soles with floor mat.), quantified by Likert scale measurement technique. The data was collected at the end of the day to interpret the results. Phyllis M. King, (2002), concluded that no significant differences in fatigue or discomfort were found when comparing the overall effects of using the floor mat to wearing the shoe in-soles or the combined condition.

Lauranna Li, et al. (2001), evaluated fatigue and discomfort of four individuals standing in laboratory environment, for two hours on three different surfaces (softer floor mat, softest floor mat and concrete floor), quantified by surface electromyography and Likert scale measurement technique. The data was collected at the interval of 0, 15, 45, 75 and 115 minutes to interpret the results. Lauranna Li, et al. (2001), concluded that a strong interaction of surface compressibility and standing duration was observed in the variables studied. Overall, the presence of anti-fatigue matting resulted in less discomfort, tiredness, fatigue compared to a concrete surface. However, standing duration was also shown to be a critical component. Also, the compressibility of the surface was a significant factor.

Rakié Cham, et al. (1999), evaluated fatigue and discomfort of individuals standing in laboratory environment, for four hours on two different surfaces (floor mat placed over force plate and vinyl tile floor), quantified by center of pressure, surface electromyography, skin temperature and leg volume measurement technique. The data was collected at the interval of fifteen minutes. Rakié Cham, et al. (1999), concluded that the hard floor and floor mat consistently yielded worse performance. The relationships between the mat material properties and fatigue measures suggest that floor performance increased with greater elasticity and stiffness, and lower energy absorption.

Pascal Madeleine, et al. (1997), evaluated discomfort of ten individuals standing in laboratory environment, for two hours on two different surfaces (14.5 mm polyurethane mat and aluminum plate), quantified by center of pressure, Intramuscular-ElectroMyoGraphy (iEMG), skin temperature and leg volume measurement technique. The data was collected at the interval of fifteen minutes to interpret the results. Pascal Madeleine, et al. (1997), concluded that the experimentally induced pain influenced postural activity, underlining central

https://dx.doi.org/10.22161/ijaers/3.10.15 *ISSN: 2349-6495(P) | 2456-1908(O)*

interactions between proprioceptors and nociceptors. The results highlighted a higher feeling of comfort when standing on the soft surface. In addition, postural activity was lower when standing on the soft surface, but the activity was sufficient to prevent swelling of the lower legs.

III. DISCUSSION

In earlier studies, most researchers used subjective methods (Javad Aghazadeh, et al. (2015); Yen-Hui Lin, et al. (2012); Phyllis M. King, (2002); Lauranna Li, et al. (2001)) to collect data and interpret their results, whereas very few researchers used objective methods (Jeremy Brownie, et al. (2015); Javad Aghazadeh, et al. (2015); H. Isa, et al. (2013); Yen-Hui Lin, et al. (2012); Lauranna Li, et al. (2001); Rakié Cham, et al. (1999); Pascal Madeleine, et al. (1997)) to collect data and interpret their results.

Most ergonomic assessment tools and techniques are predominantly intended for specific region and place only. Subjective methods are based on personal opinions, interpretations, point of views, emotions and judgment. They are often considered unreliable for decision making. Whereas, objective methods are fact-based, measurable and observable. They often give almost reliable results for decision making.

In the similar type of studies earlier, researchers evaluated individual responses based on pain, fatigue and discomfort (Jeremy Brownie, et al. (2015); Javad Aghazadeh, et al. (2015); H. Isa, et al. (2013); Yen-Hui Lin, et al. (2012); Phyllis M. King, (2002); Lauranna Li, et al. (2001); Rakié Cham, et al. 1999); Pascal Madeleine, et al. 1997)).

Based on Oxford Dictionary (As of 10 October 2016, English, Oxford Living Dictionaries - Oxford Dictionaries, "www.en.oxforddictionaries.com") the terms, fatigue, pain and discomfort are defined as follows:

- Fatigue: extreme tiredness resulting from mental or physical exertion or illness; a lessening in one's response to or enthusiasm for something, caused by overexposure; a reduction in the efficiency of a muscle or organ after prolonged activity
- Pain: highly unpleasant physical sensation caused by illness or injury
- Discomfort: slight pain

The studies mentioned above assessed the individual performance on prolonged standing. In these type of studies, fatigue can be used to interpret results, however pain or discomfort are very subjective factors and thus it is inappropriate to determine the individual performance using these terms. Fatigue too is a by-product of mental or physical exertion and each individual perceives it differently.

Moreover, only fatigue doesn't influence the overall performance of an individual, there are other factors too. Hence, the assessment of physical exertion or the energy expenditure during a particular task can give more accurate results as compared to other factors.

Physical exertion directly impacts individual performance. Nurhayati Mohd Nur, et. al., (2015), assessed the effects of energy expenditure rate on work productivity performance at different levels of production standard time and concluded that working with an energy expenditure rate that is either equal to or above the maximum energy expenditure rate of the tasks results in decreased work productivity performance.

Many researchers conducted their study for short duration of time (Javad Aghazadeh, et al. (2015); Lauranna Li, et al. (2001); Pascal Madeleine, et al. (1997)). However, it was observed that to determine the effects of prolonged standing, longer duration of experimentation is required. The duration of experimentation should be at least one shift long (i.e. 6 to 8 hours).

During their study, some researcher took few readings that too at long intervals of the time (e.g. Yen-Hui Lin, et al. (2012) and Phyllis M. King, (2002) collected reading once in a day at end of the day. Jeremy Brownie, et al. (2015), H. Isa, et al. (2013) and Yen-Hui Lin, et al. (2012) took reading start, middle and end of the day. etc.…). However, to achieve accurate results, frequent readings at shorter intervals of time are required.

It has been reported that use of soft mat may help reduce adverse health effects of prolonged standing than hard floor (Javad Aghazadeh, et al. (2015); H. Isa, et al. (2013); Yen-Hui Lin, et al. (2012); Lauranna Li, et al. (2001); Rakié Cham, et al. (1999) and Pascal Madeleine, et al. (1997)). While some researchers (Jeremy Brownie, et al. (2015) and Phyllis M. King, (2002)) found that there are no significant differences in fatigue while using soft mat.

IV. CONCLUSION

On analyzing past work, following points were noted:

- To know the impact of different conditions on performance of an individual while standing, many researchers used subjective as well as objective methods. Subjective methods are often considered unreliable for decision making, whereas objective methods often give almost reliable results for decision making.
- Fatigue is more appropriate factor than pain or discomfort when it comes to evaluate individual performance.

https://dx.doi.org/10.22161/ijaers/3.10.15 ISSN: 2349-6495(P) | 2456-1908(O)

- Researchers need to concentrate more on physical exertion to analyses performance of any individual, rather than on its by-products e.g. fatigue, pain or discomfort.
- Studies need to be carried out on large population and for longer duration with continuous observation to further understand and estimate the accurate effects of prevalent methods to reduce health risk.
- Most of the researchers reported that use of soft mat may help reduce adverse health effects of prolonged standing, but some concluded that it doesn't have significant effect.

REFERENCES

[1] H. Isa, A. R. Omar, A. R. Ismail, R. K. Seri, A. Hambali, M. A. Rahman, A. Rohana, 2013. "Electromyography analysis associated with prolonged standing in metal stamping industry", Journal of Advanced Manufacturing Technology, 7(1).

[2] Javad Aghazadeh, Mahmoud Ghaderi, Mahmood–reza Azghani, Hamid–reza Khalkhali, Teimour Allahyari, Iraj Mohebbi, 2015. "Anti-fatigue mats, low back pain, and electromyography: An interventional study", International Journal of Occupational Medicine and Environmental Health, 28(2):347-56. doi: 10.13075/ijomeh.1896.00311.

[3] Jeremy Brownie, Bernard J. Martin, 2015. "Muscle fatigue and discomfort associated with standing and walking: Comparison of work surfaces", The Proceedings of the 19th Triennial Congress of the International Ergonomics Association. Melbourne, August 9-14.

[4] Lauranna Li, Mardon B. Frazer, 2001. "Prolonged standing and the effect of work surface compressibility on Discomfort, Tiredness, Muscle Fatigue and Productivity", The Proceedings of the SELF-ACE 2001 Conference – Ergonomics for changing work, 5:146-148.

[5] Nurhayati Mohd Nur, Siti Zawiah Md Dawal, Mahidzal Dahari, Junedah Sanusi, 2015. "The effects of energy expenditure rate on work productivity performance at different levels of production standard time", Journal of Physical Therapy Science, 27(8): 2431-2433. doi: 10.1589/jpts.27.2431.

[6] Pascal Madeleine, Michael Voigt, Lars Arendt-Nielsen, 1997. "Subjective, physiological and biomechanical responses to prolonged manual work performed standing on hard and soft surfaces", European Journal of Applied Physiology and Occupational Physiology, 77(1-2): 1-9. doi: 10.1007/s004210050292.

[7] Phyllis M. King, 2002. "A comparison of the effects of floor mats and shoe in-soles on standing fatigue", Applied Ergonomics, 33(5):477-84· doi: 10.1016/S0003-6870(02)00027-3.

[8] Rakié Cham, Mark S. Redfern, 1999. "Influence of flooring on objective standing fatigue measures", The Proceedings of the 23rd Annual Meeting of the American Society of Biomechanics University of Pittsburgh, October 21-23.

[9] Shaikh Abdus Samad, R. D. Shelke, 2016. "Health Effect of Prolonged Standing at Work & Its Control Measures: A Review", International Journal of Engineering Research and General Science, 4(2):527-529.

[10] Walter F. Stewart, Judith A. Ricci, Elsbeth Chee, David Morganstein, Richard Lipton, 2003 "Lost Productive Time and Cost Due to Common Pain Conditions in the US Workforce", The Journal of the American Medical Association, 290(18):2443-2454. doi: 10.1001/jama.290.18.2443.

[11] Yen-Hui Lin, Chih-Yong Chen, Min-Hsien Cho, 2012. "Influence of shoe/floor conditions on lower leg circumference and subjective discomfort during prolonged standing", Applied Ergonomics, 43(5):965–970. doi:10.1016/j.apergo.2012.01.006.

[12] Wikipedia, the free encyclopedia, "www.en.wikipedia.org", 10 October 2016

[13] International Ergonomics Association (IEA), "www.iea.cc", 10 October 2016

[14] English, Oxford Living Dictionaries - Oxford Dictionaries, "www.en.oxforddictionaries.com", 10 October 2016